

# Demonstration of Human-Autonomy Teaming Principles

HAT Lab

September 2016

# Background

- Problem
  - *Incidents and accidents result from pilots failing to understand increasingly sophisticated aircraft systems.*
  - *These systems are often brittle and rarely degrade gracefully.*
  - *Human involvement with increasingly autonomous systems must adjust to allow for a more dynamic relationship involving cooperation and teamwork.*
- Goal
  - *Develop a framework for human-autonomy teaming in aviation and provide guidelines and recommendations for its application. The framework will identify critical aspects of human-autonomy teaming and provide a mechanism for evaluation.*

# Current Study

- Pilot study to introduce Human-Autonomy Teaming (HAT) principles
- Builds on earlier ground station to minimize development
- Demonstrate, evaluate, and refine HAT principles necessary for the development of a HAT research framework

# What is HAT

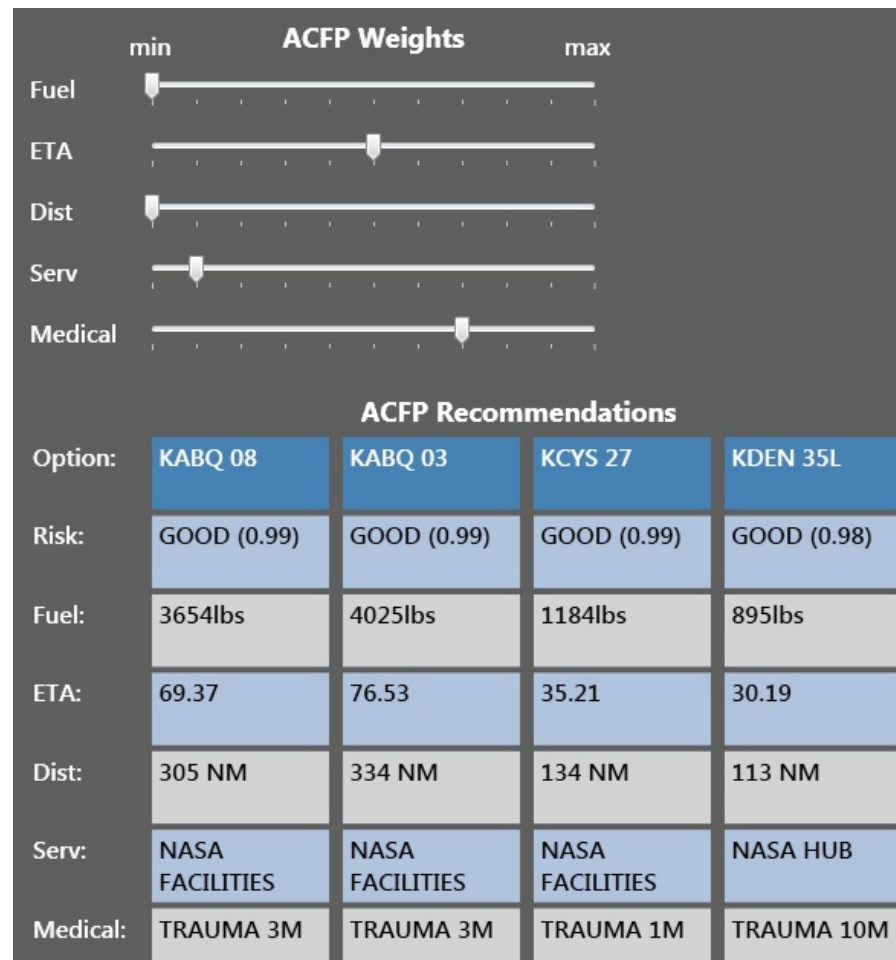
- Human-Autonomy Teaming (HAT) is characterized by collaboration between the human and the autonomy, rather than just a decision support aid. They share goals, information and a common language.
- HAT extends CRM principles used between human operators to interactions between humans and automation resulting in cross validation of actions and situation awareness by both operators and automation.
  - *Humans have flexibility and “common sense” to recognize situations that are out of the bounds the automation was programmed for.*
  - *Automation has “infinite” vigilance and the ability to monitor many inputs simultaneously so it can more quickly recognize off-nominal situations.*

# HAT Principles

- Transparency
  - *Good CRM between humans requires team members to understand what the others are doing and why. When teaming with automation, motivation is often less intuitively obvious, so transparency about reasoning is necessary.*
- Negotiation
  - *Good CRM between humans requires people with different information to enter a dialog about how best to achieve their goals.*
- Shared Language/Communication
  - *Good CRM between humans requires an explicit communication about goals and actions. Developing analogous communication for HAT requires a shared language.*
- Human Directed
  - *Good CRM between humans requires someone to be responsible for final decisions and that such decisions should be explicit. We believe that is going to be the human. It follows that the human should be giving explicit direction to the automation.*

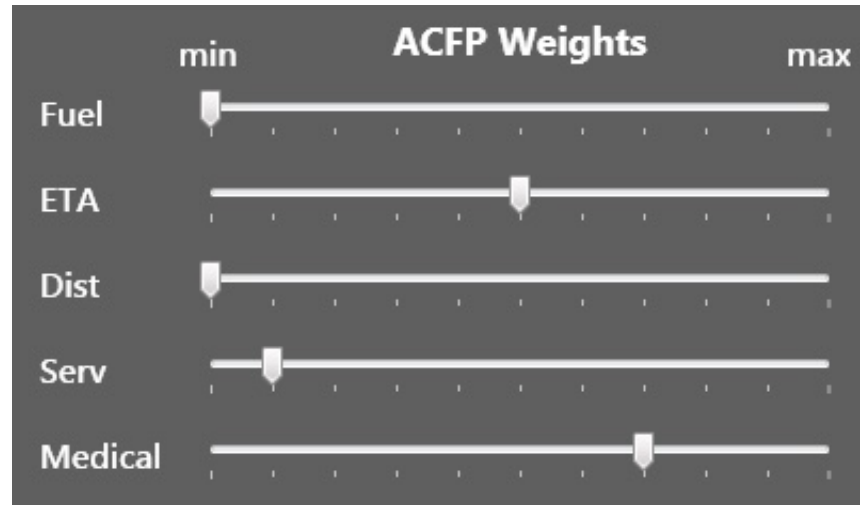
# Adding HAT Principles to Ground Station

Transparency: ACFP (a recommender system) shows diver reasoning and factor weights.



# Adding HAT Principles to Ground Station

Negotiation: Operators can change factor weights to match their priorities.



# Adding HAT Principles to Ground Station

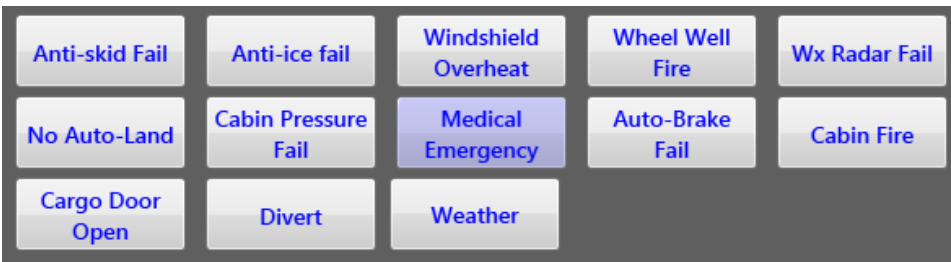
Shared Language/Communication: Numeric output from ACFP was found to be misleading by pilots. Display now uses English categorical descriptions.

ACFP Recommendations				
Option:	KABQ 08	KABQ 03	KCYS 27	KDEN 35L
Risk:	GOOD (0.99)	GOOD (0.99)	GOOD (0.99)	GOOD (0.98)
Fuel:	3654lbs	4025lbs	1184lbs	895lbs
ETA:	69.37	76.53	35.21	30.19
Dist:	305 NM	334 NM	134 NM	113 NM
Serv:	NASA FACILITIES	NASA FACILITIES	NASA FACILITIES	NASA HUB
Medical:	TRAUMA 3M	TRAUMA 3M	TRAUMA 1M	TRAUMA 10M



# Adding HAT Principles to Ground Station

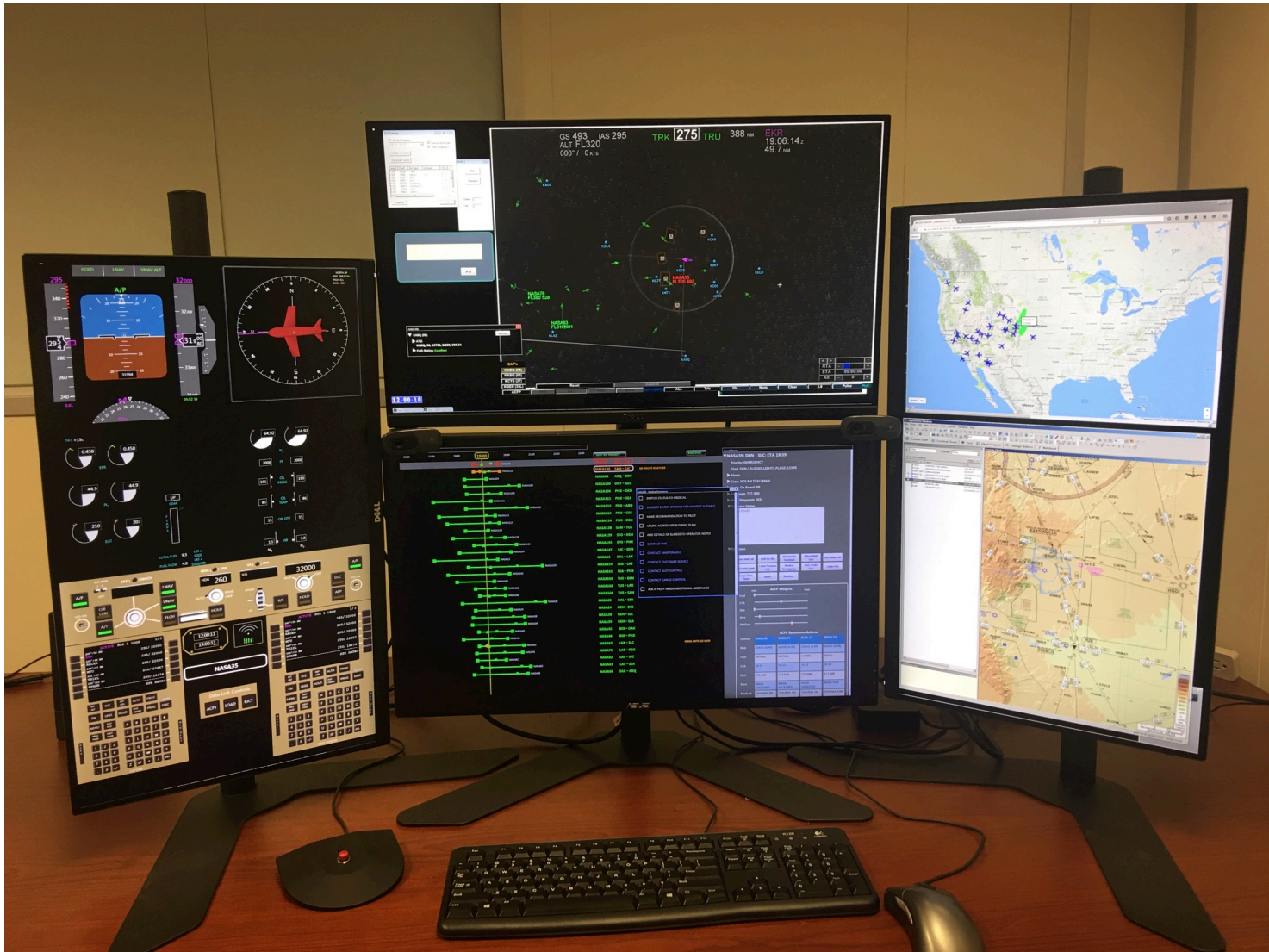
Human-Directed: Operator calls “Plays” to set system goals.



NASA35 - Medical Emergency

- ☐ SWITCH STATUS TO MEDICAL
- ☐ SUGGEST DIVERT OPTIONS FOR NEAREST SUITABLE
- ☐ MAKE RECOMMENDATION TO PILOT
- ☐ UPLINK AGREED UPON FLIGHT PLAN
- ☐ ADD DETAILS OF ILLNESS TO OPERATOR NOTES
- ☐ CONTACT EMS
- ☐ CONTACT MAINTENANCE
- ☐ CONTACT CUSTOMER SERVICE
- ☐ CONTACT SLOT CONTROL
- ☐ CONTACT CARGO CONTROL
- ☐ ASK IF PILOT NEEDS ADDITIONAL ASSISTANCE

# Ground Station



Enables enhanced ground support of multiple aircraft

# Demonstration Design

- Independent Variable: No HAT vs HAT
  - *No HAT: Original Build 1 ground station (with minor bug fixes)*
  - *HAT: Inclusion of Transparency, Negotiation, Shared Language, and Pilot Directed interface improvements above*
- Seven Participants (4 Dispatchers, 3 Pilots)
- Dependent Variables:
  - *Behavioral*
    - Eye movements/scan patterns (to determine which display the operator is fixated on)
    - Operator inputs between recommendation and acceptance: does operator bring up charts, or modify view of charts prior to accepting/rejecting recommendation?
  - *Subjective*
    - Subjective responses: during the scenario (ATWIT workload, recommendation quality) and at the end of the scenario (workload, situation awareness, trust, etc.)

# Scenarios

- Two scenarios:
  - *Approximately 50 minutes each*
  - *Winter and Summer weather*
  - *Approximately 6 divert events each*
- Divert decision made using automation (ACFP)
  - *Some scenarios require immediate action and landing at nearest suitable airport (e.g., Aft Cargo Door Open)*
  - *Some scenarios require a decision to divert without time pressure (e.g., Airport Weather)*
- Example Events
  - *Wheel Well Fire*
  - *Diversion For Medical Emergency*
  - *Airport Weather + Weather Radar Fail*
  - *Aft Cargo Door Open*
  - *Airport Weather Affecting Multiple Aircraft*
  - *Fire In Lavatory*
  - *Airport Weather + Antiskid Inop*

# Subjective Results

Participants preferred the HAT displays and automation with regard to

- *keeping up with operationally important issues (avg. 8.57)*
- *ensuring they had enough situation awareness for the task (avg. 8.57)*
- *reducing the workload necessary for the task (avg. 8.29)*
- *integrating information from a variety of sources (avg. 8.29)*
- *efficiency (avg. 8.14)*

Overall, participants preferred interacting with the automation in the HAT condition (avg. 8.43).

Scale: 1 (No HAT) – 5 (No Preference) – 9 (HAT)

# Debrief

- Transparency/Shared Language
  - *“This [the table] is wonderful.... You would not find a dispatcher who would just be comfortable with making a decision without knowing why.”*
- Negotiation
  - *“The sliders was [sic] awesome, especially because you can customize the route.... I am able to see what the difference was between my decision and [the computer’s decision].”*
- Human-Directed
  - *“This one was definitely awesome. Sometimes [without HAT] I even took my own decisions and forgot to look at the QRH because I was very busy, but that didn’t happen when I had the HAT.*